EPICS Detector and Feedback Software

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Outline

- EPICS Interface to Canberra Electronics
- EPICS Interface to XIA DXP Electronics for Energy Dispersive Detectors
- ccdApp: Generic EPICS Interface to Area Detectors
- smartControl: Using Bruker SMART to Control EPICS Experiments
- Generic Feedback under EPICS
- APS Beam Position Monitor and EPICS Software New motor record device and driver support developments

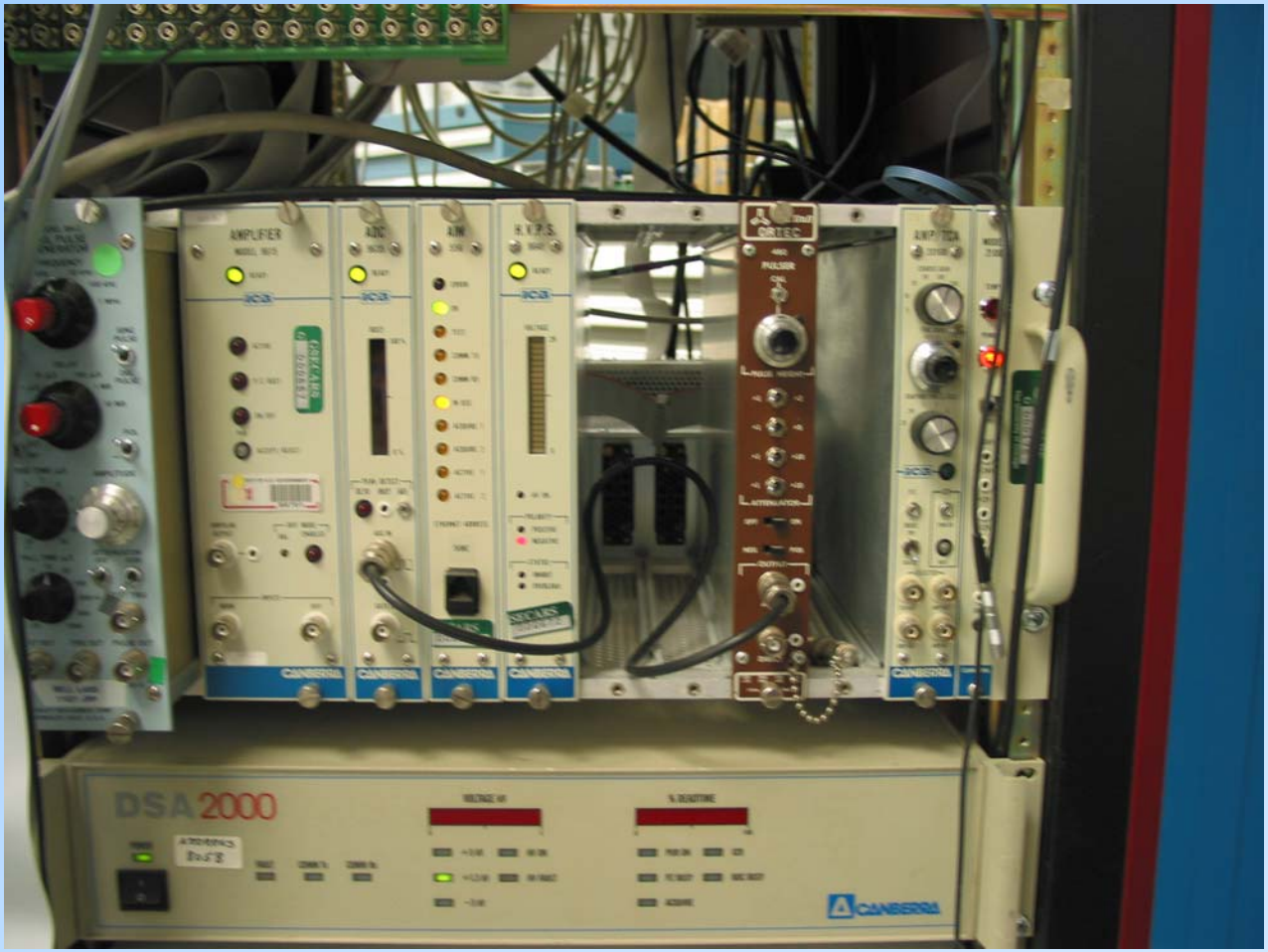
mcaApp – support for multichannel analysers

- mcaRecord
  - Like waveform record with lots of additional fields
  - Start/stop acquisition
  - Preset live/real time
  - Regions of interest – total and net counts, can be used as EPICS scan record detector like a scaler
  - Device independent
  - Primary device support uses asyn – also device independent
    - Drivers implement int32, float64, int32array asyn interfaces

mcaApp – support for multichannel analyzers

- Devices supported
  - Canberra Ethernet AIM MCAs
  - Canberra ICB modules (amplifier, ADC, HVPS, TCA, DSP)
  - SIS multichannel scaler
  - APS quad electrometer
  - Acromag IP330 A/D as a transient digitizer (16 channels, ~2kHz)
  - XIA Saturn (=Radiant Vortex)
  - XIA DXP-2X CAMAC module
  - XIA xMAP PXI module

Canberra electronics

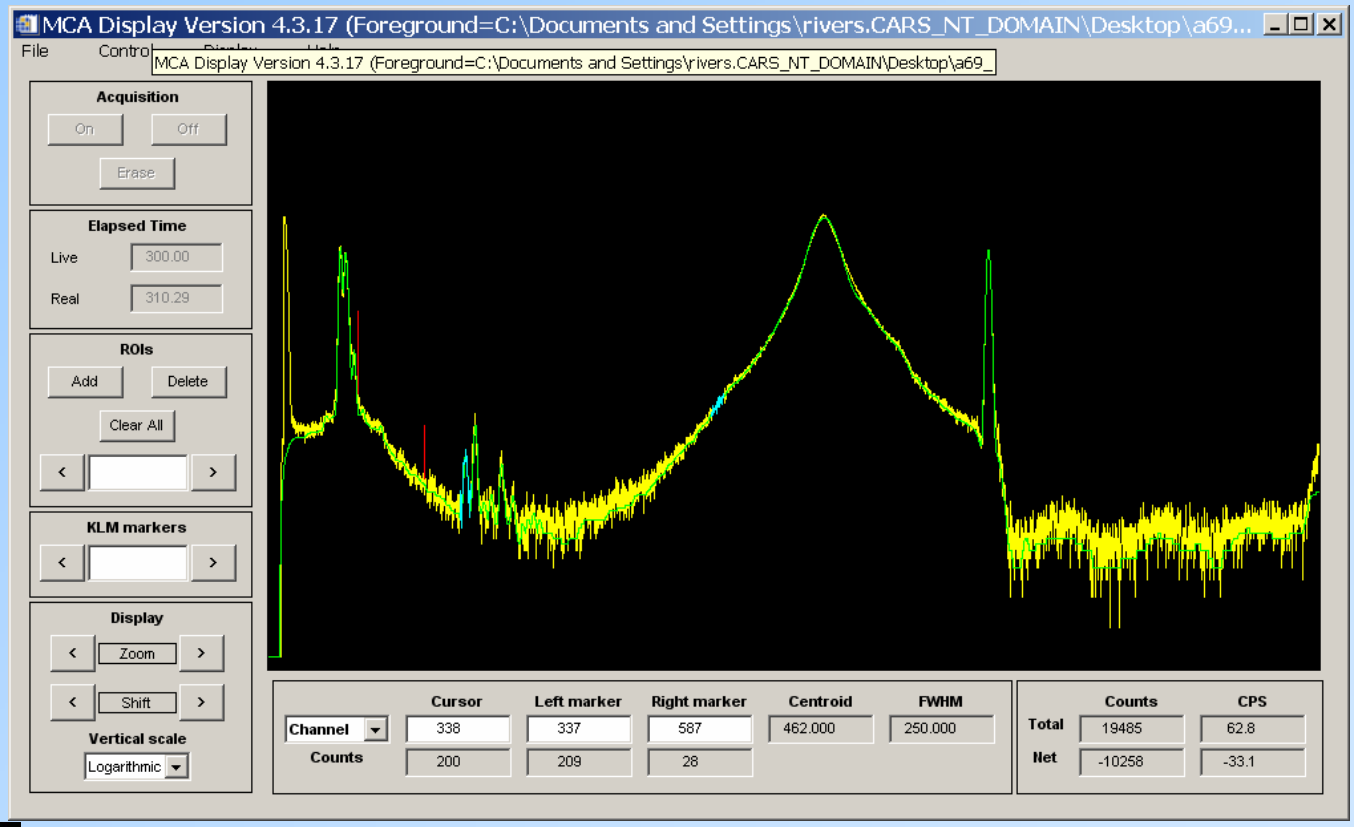


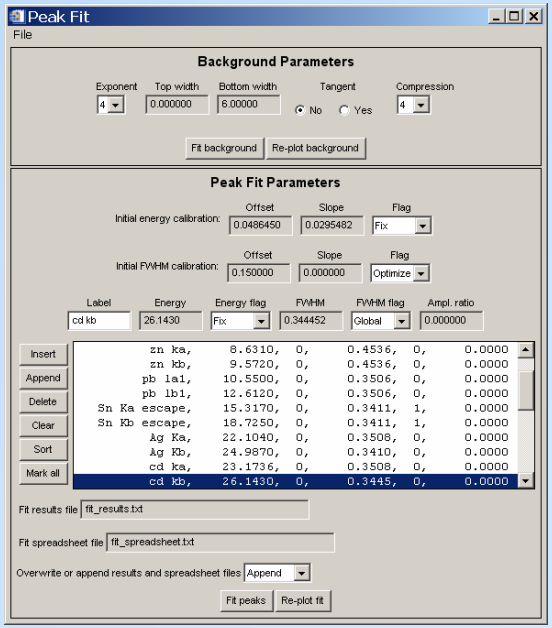
Canberra electronics

- AIM Ethernet MCA
- Non-TCP/IP protocol
- EPICS support uses low-level Ethernet hooks on vxWorks, libnet and libpcap on Linux
  - New network layer using LLC sockets working on Linux and vxWorks at Diamond.
- Based on library from Canberra for middle layer between asyn driver and low-level I/O
- This is a common model for device support. On EPICS the low-level and high level parts need to be written, the middle layer can come from the manufacturer.

IDL MCA Display

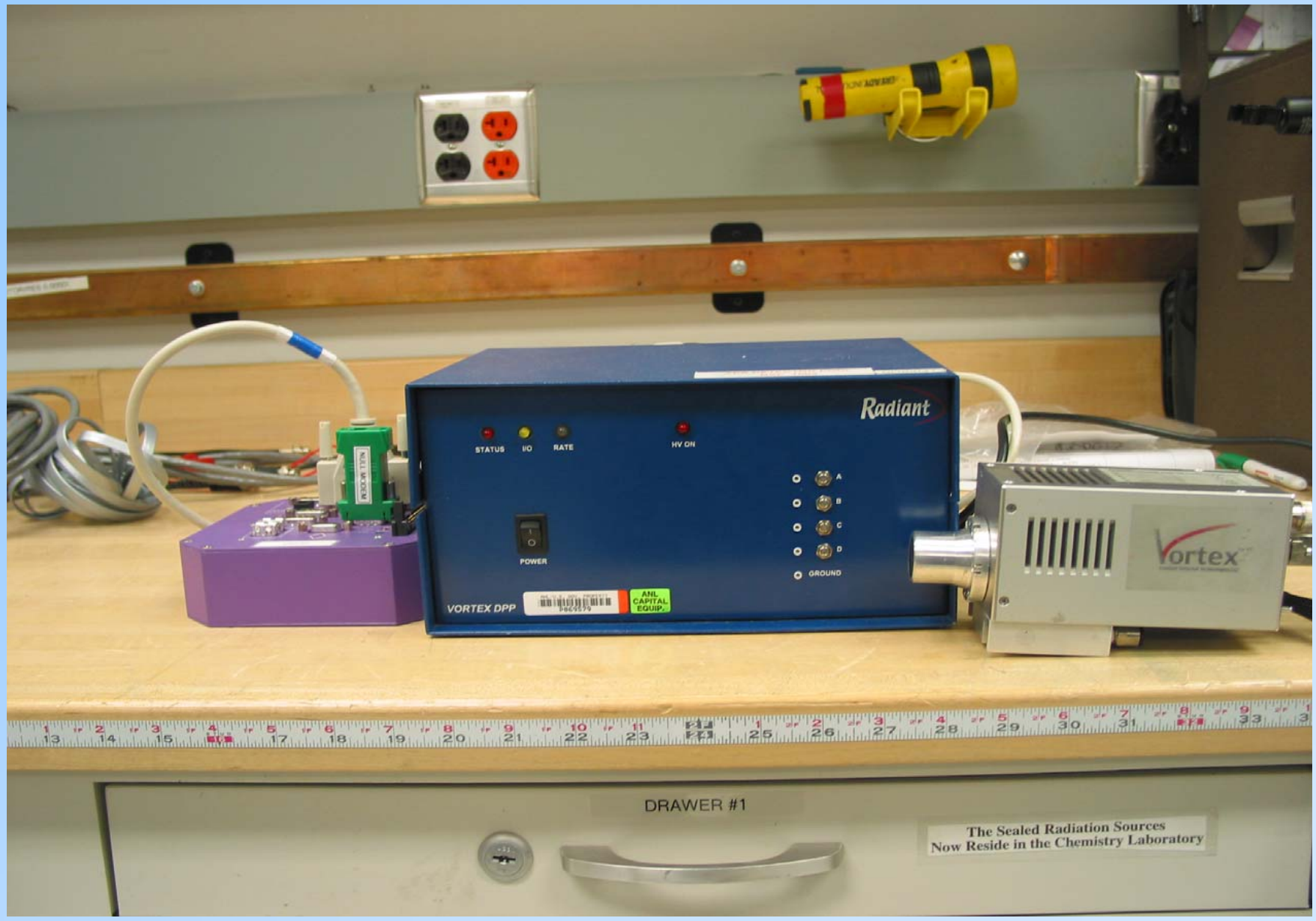
- mcaDisplay
  - Full-featured program for displaying, controlling EPICS multi-channel analysers, including peak fitting
  - Uses epics_mca class library, and exports mca_display class, so it can be controlled by other IDL applications





Fast DSP Electronics for EDS Detectors

- Digital signal processing based x-ray spectrometers from X-ray Instrumentation Associates (XIA).
- Standalone (Saturn) for single-element detectors. Runs under EPICS with Linux and Windows using EPP parallel port.
- CAMAC and PXI modules for multi-element detectors. 4 detectors/ module, very cost-effective. CAMAC runs under vxWorks, PXI under Windows.
- MCA record
  - Start and stop data acquisition
  - Readout the spectra
  - Control and read the data acquisition time
  - Define up to 32 Regions of Interest (ROIs) for computing the net or total counts in each fluorescence peak.
- DXP record
  - Provides complete control over the internal operation of the DXP
  - More than 50 adjustable parameters.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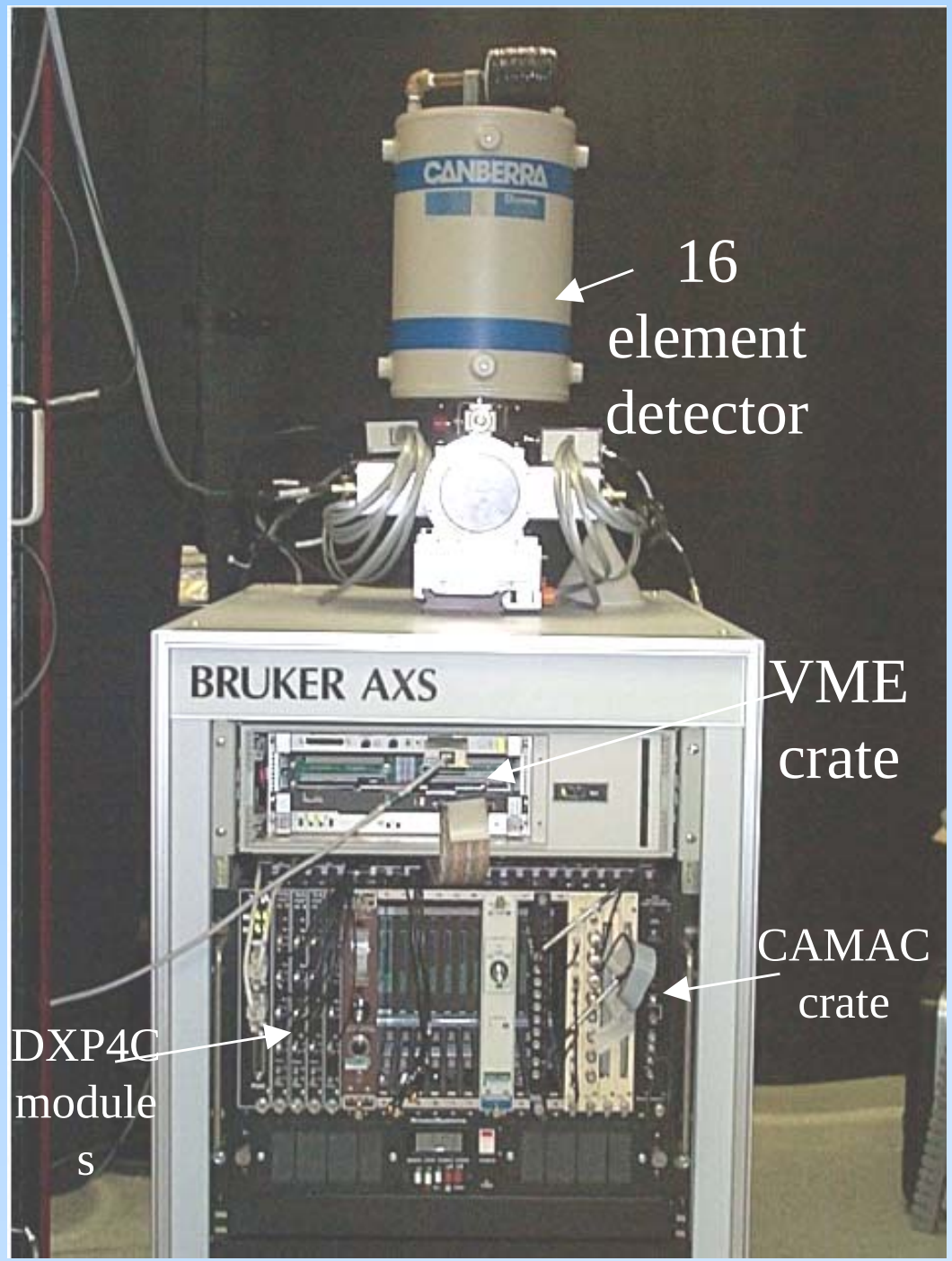
The Sealed Radiation Sources
Now Reside in the Chemistry Laboratory


CANBERRA
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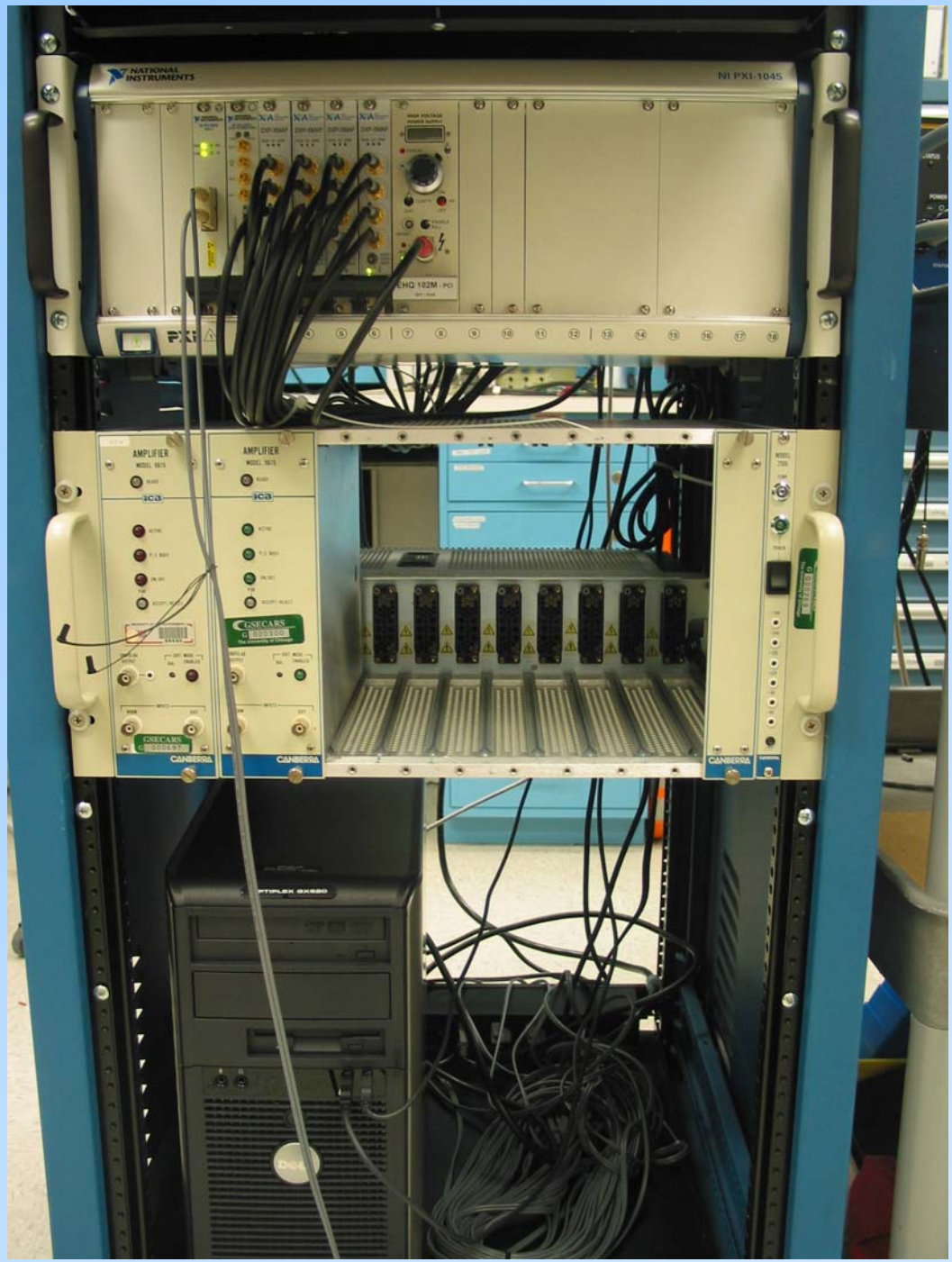
NATIONAL INSTRUMENTS
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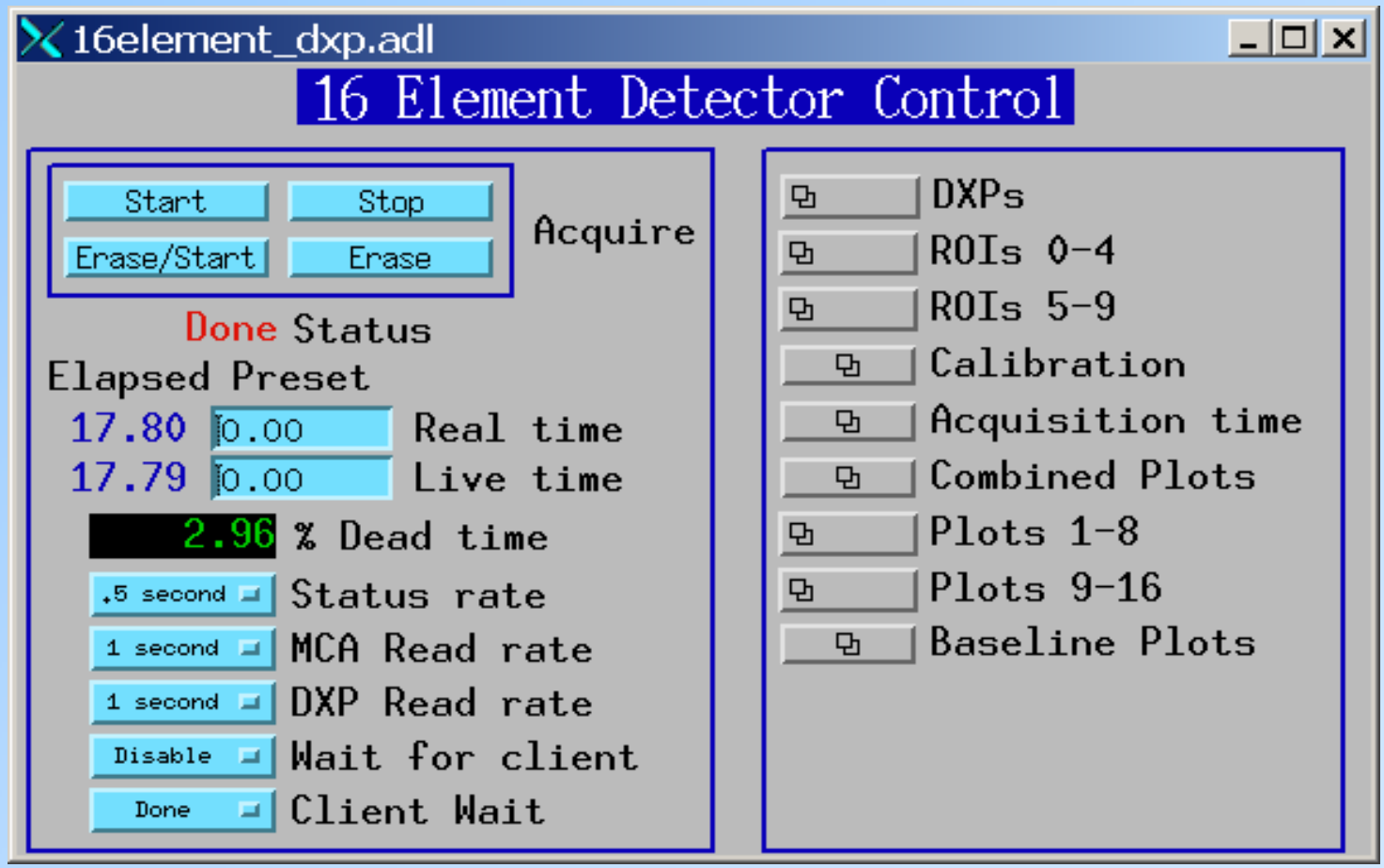
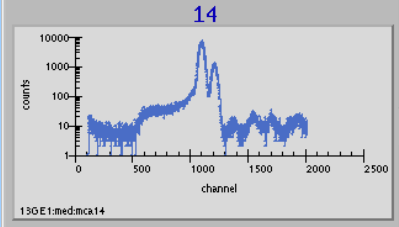
CANBERRA

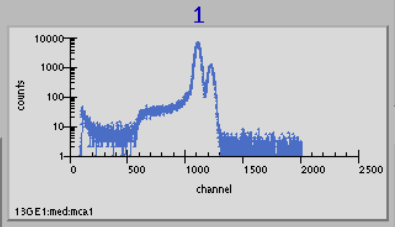
DXP EPICS control

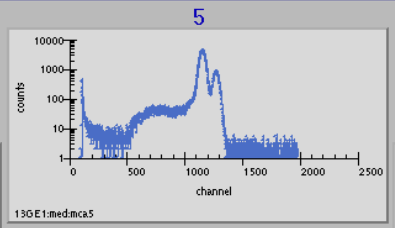


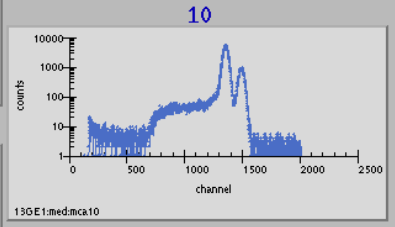
16element_plots.adl

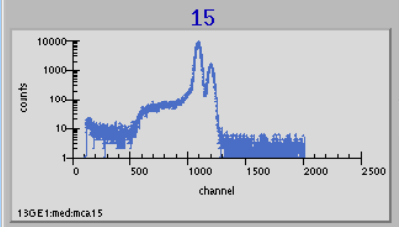
16 Element Spectra

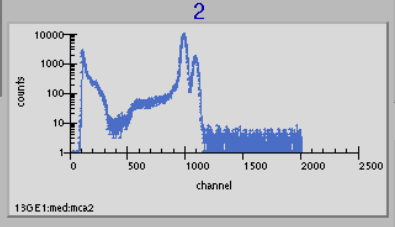


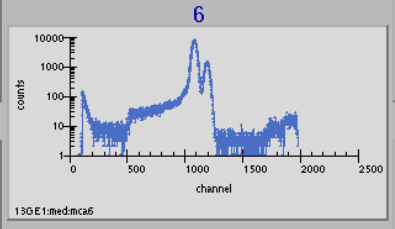


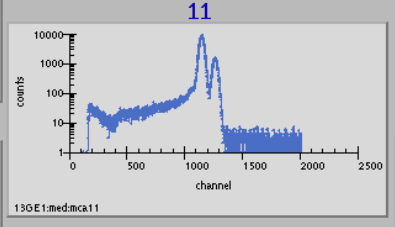


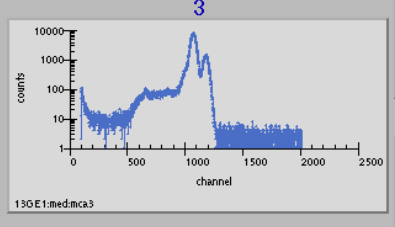


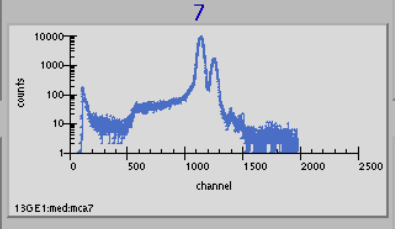


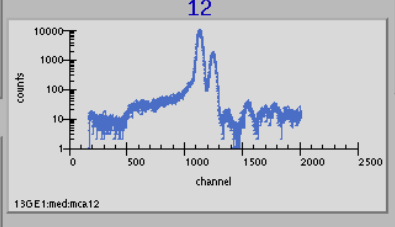


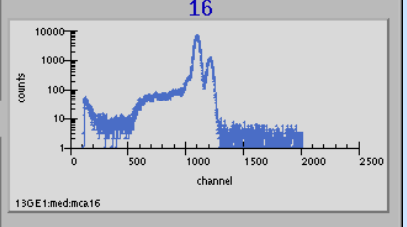


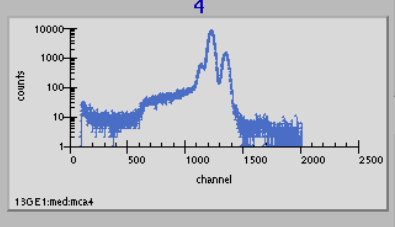


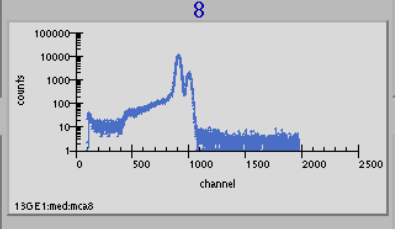


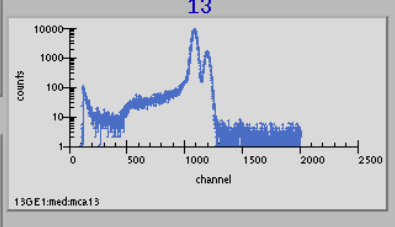


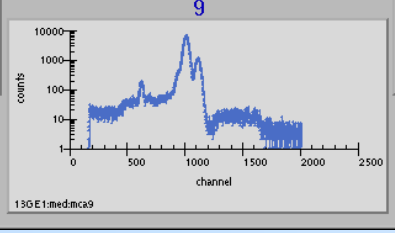




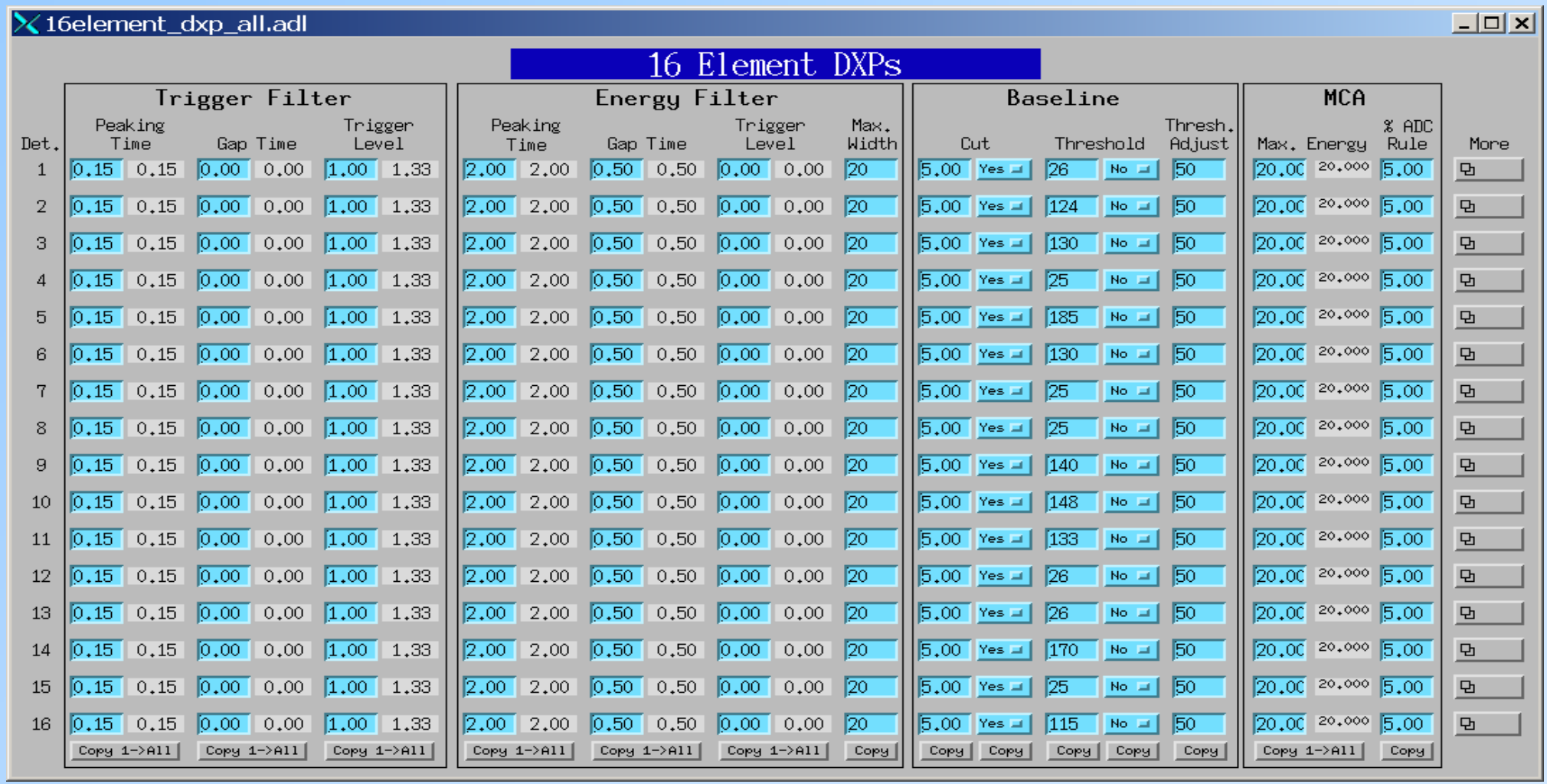








DXP EPICS control



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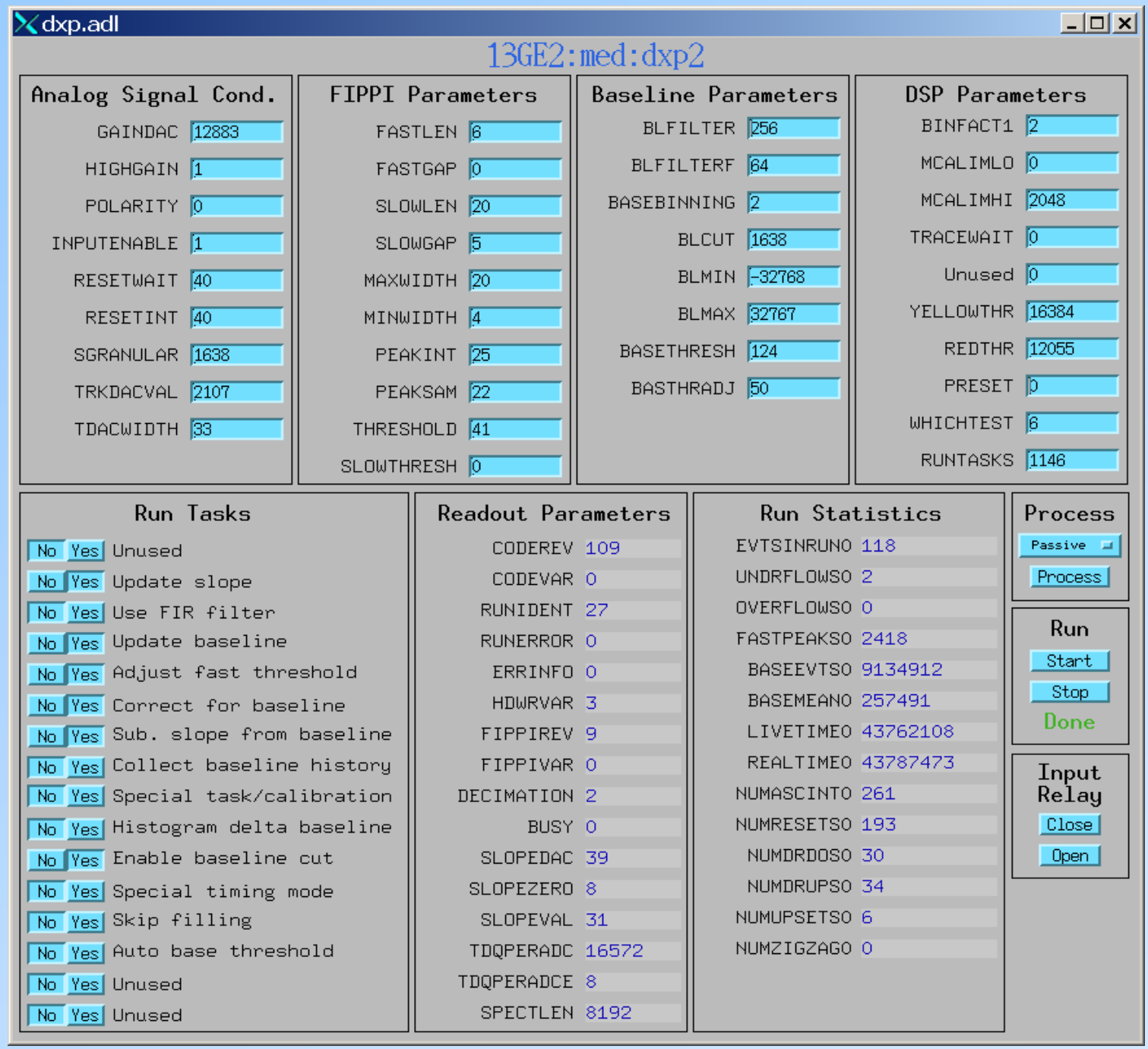
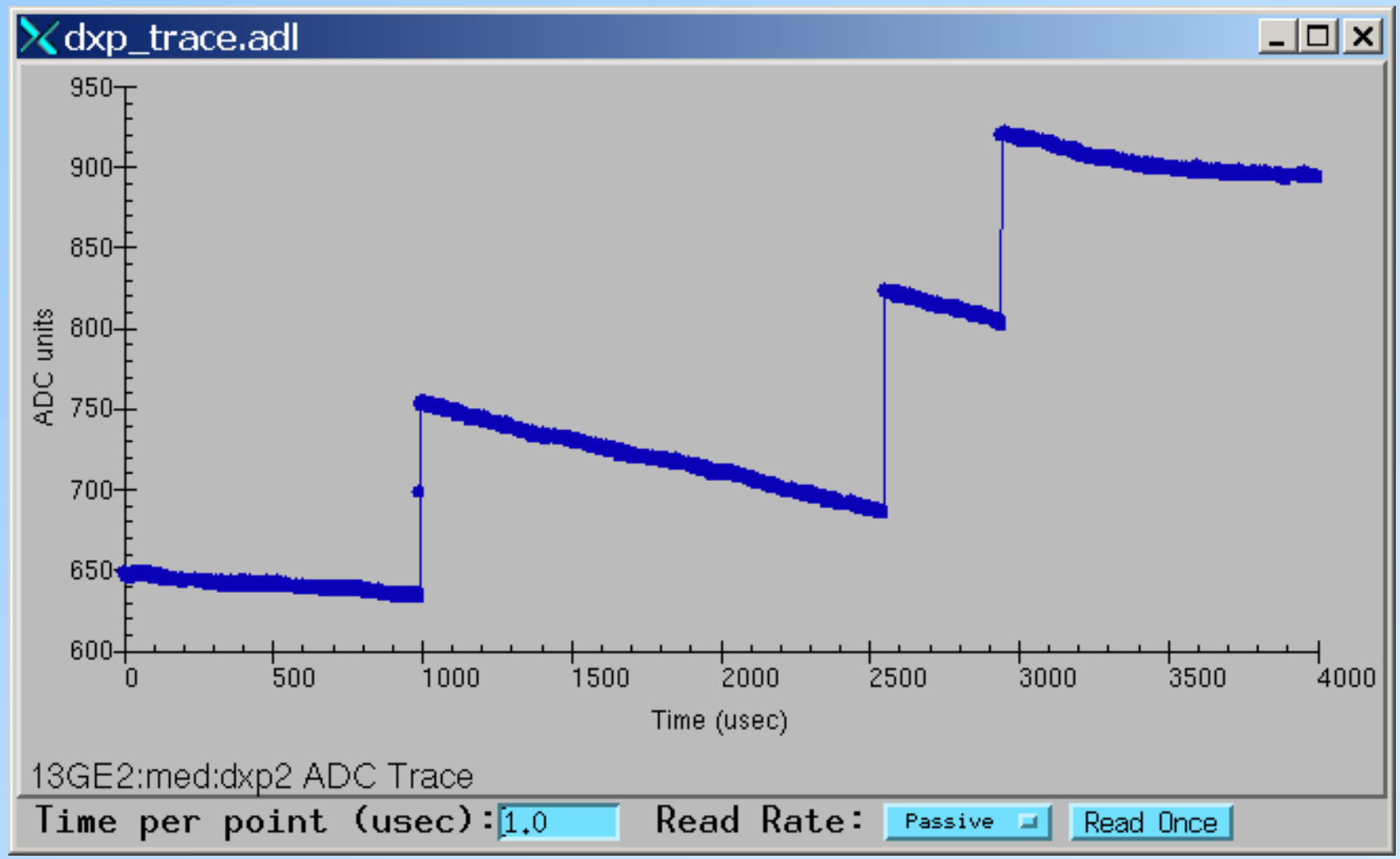
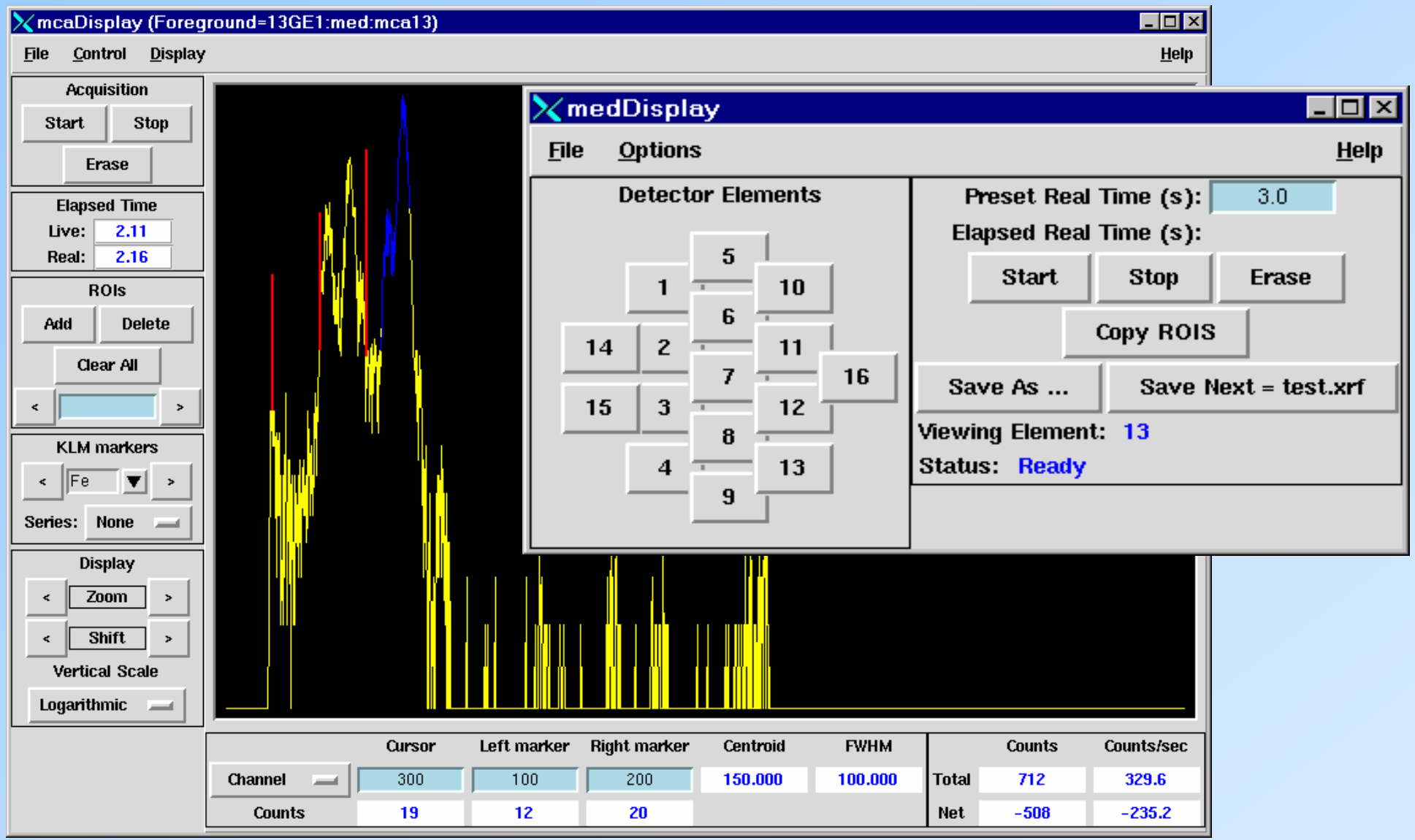


ADC Trace Mode – Digital Scope



medDisplay (IDL and Python)



ccdApp: EPICS Interface to Area Detectors

- Goal: Uniform interface for controlling area detectors (CCD, online image plates) from EPICS
  - Any EPICS client (e.g. spec, IDL, scan record) can control (at a bare minimum).
    - Exposure time
    - File name
    - Start collection, wait for completion
  - Much more control for most detectors
- Current status:
  - MAR 165 CCD (complete, in use on Sectors 1, 8, 13, 16, 18, others)
  - Roper CCD detectors (complete, in use on Sectors 12, 13, 15, 20, NSLS)
  - Bruker CCD detectors
    - Winview interface complete. In use on Sectors 13 this run.
    - SMART Service interface in planning stage. To be done?
  - MAR 345 online image plate (soon)
    - Will use scan345, but replace file I/O with socket I/O

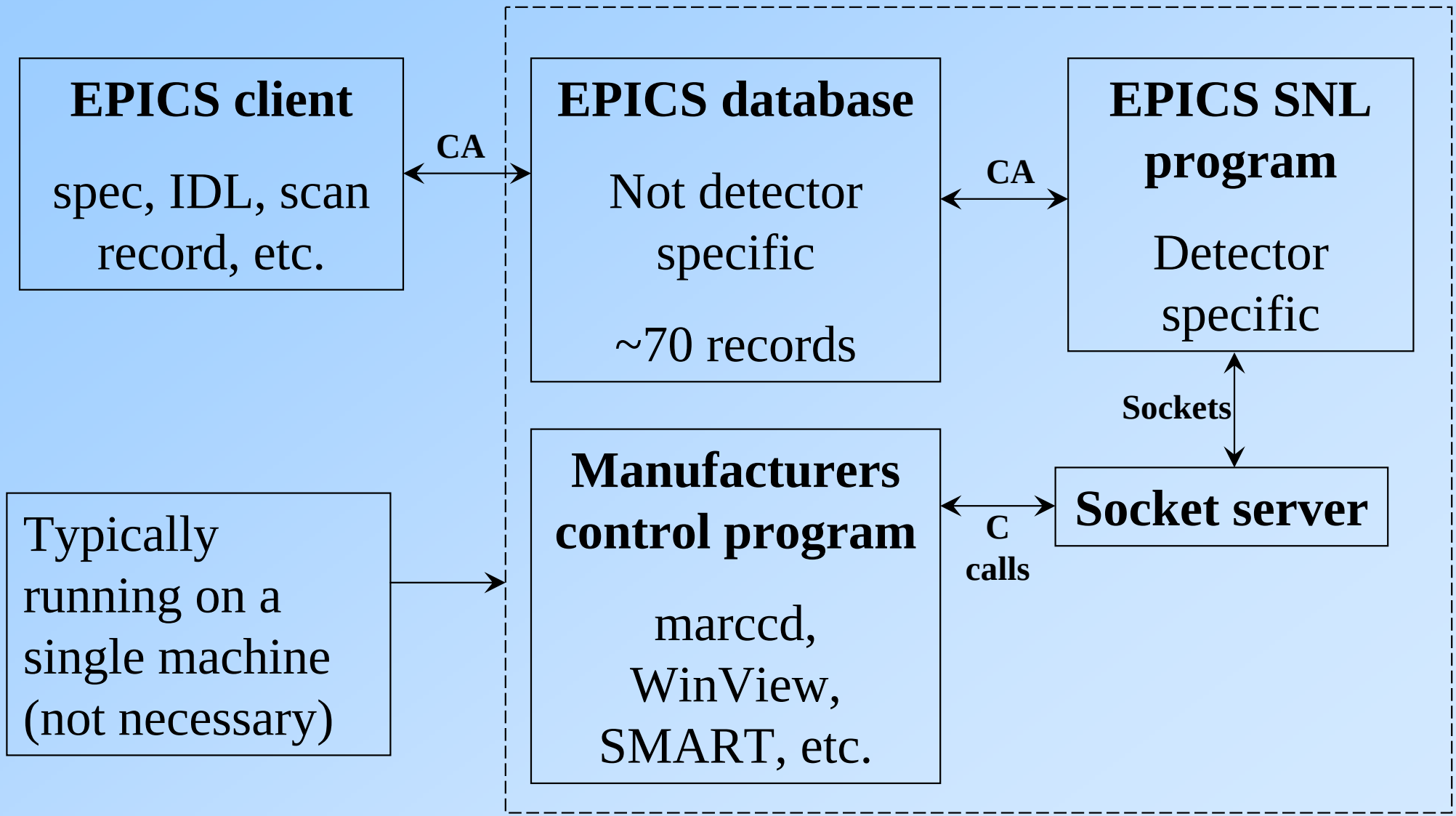
Implementation

- Use manufacturer's software for primary user interface.
  - Minimizes amount of new code
  - Uses existing file formats, unwarping algorithms, etc.
  - These programs include:
    - marccd for MAR165
    - Winview/Winspec for Roper cameras
    - WinView for Bruker cameras.
      - Requires PCI card to replace ISA card that Bruker supplies. Also new SCSI-type cable.
    - SMART for Bruker cameras
    - scan345 for MAR 345 image plate

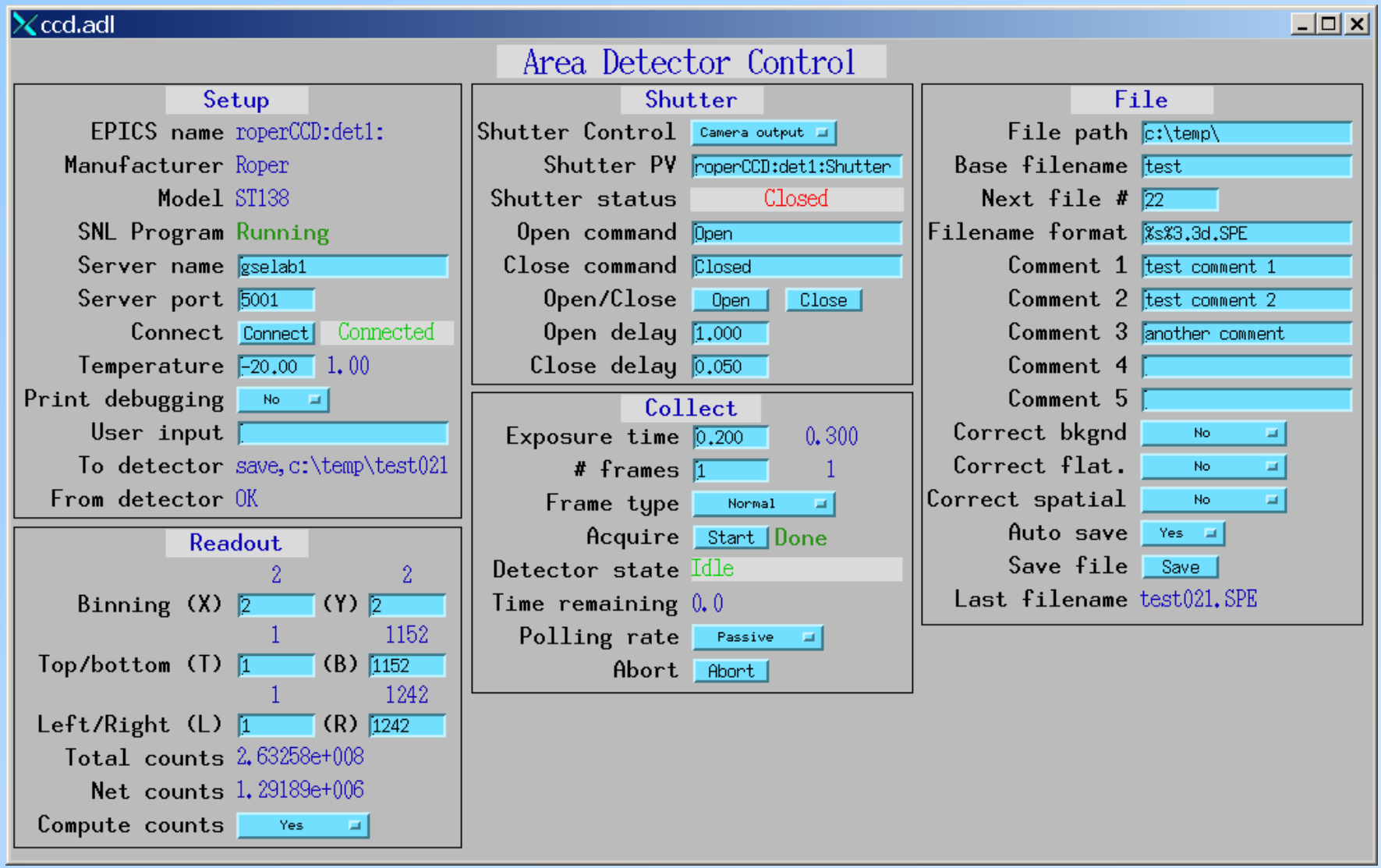
Implementation

- Control these programs from EPICS
  - Each of these programs has a “remote control” interface, typically using TCP/IP sockets
  - Using EPICS means each client (e.g. spec) does not have to know how to talk to each type of detector. Only has to know how to talk to EPICS.
- EPICS software consists of
  - Database of records (PVs), identical for all detectors
  - State-notation-language (SNL) programs, unique for each detector. Reads/writes PVs and communicates with remote control interface over sockets.
  - The database and SNL programs are typically run on the same machine that the user interface software runs on (e.g. Linux box for MAR detectors, Windows for Roper and Bruker). **No VME crate required.**

Schematic Architecture

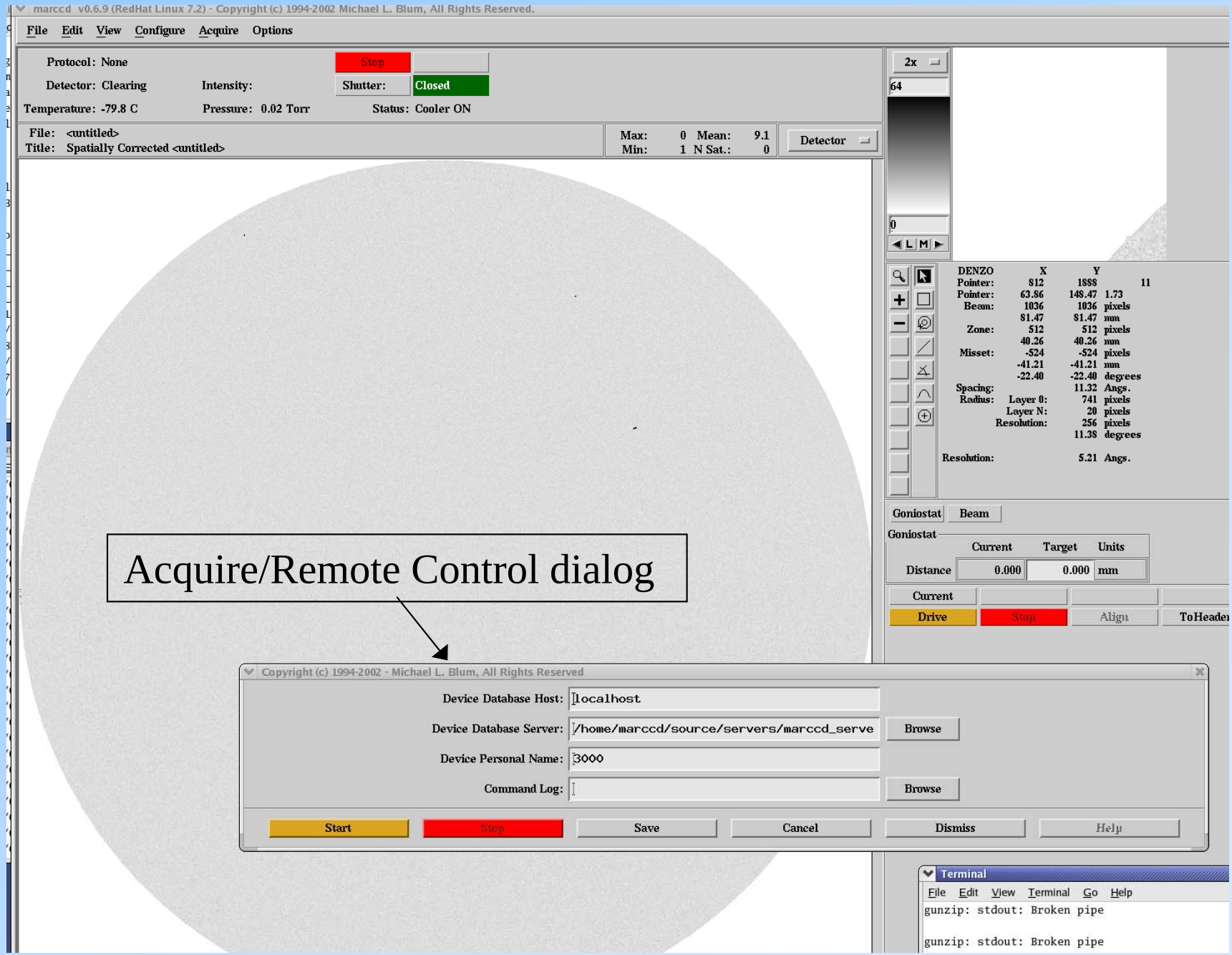


“Expert” medm screen

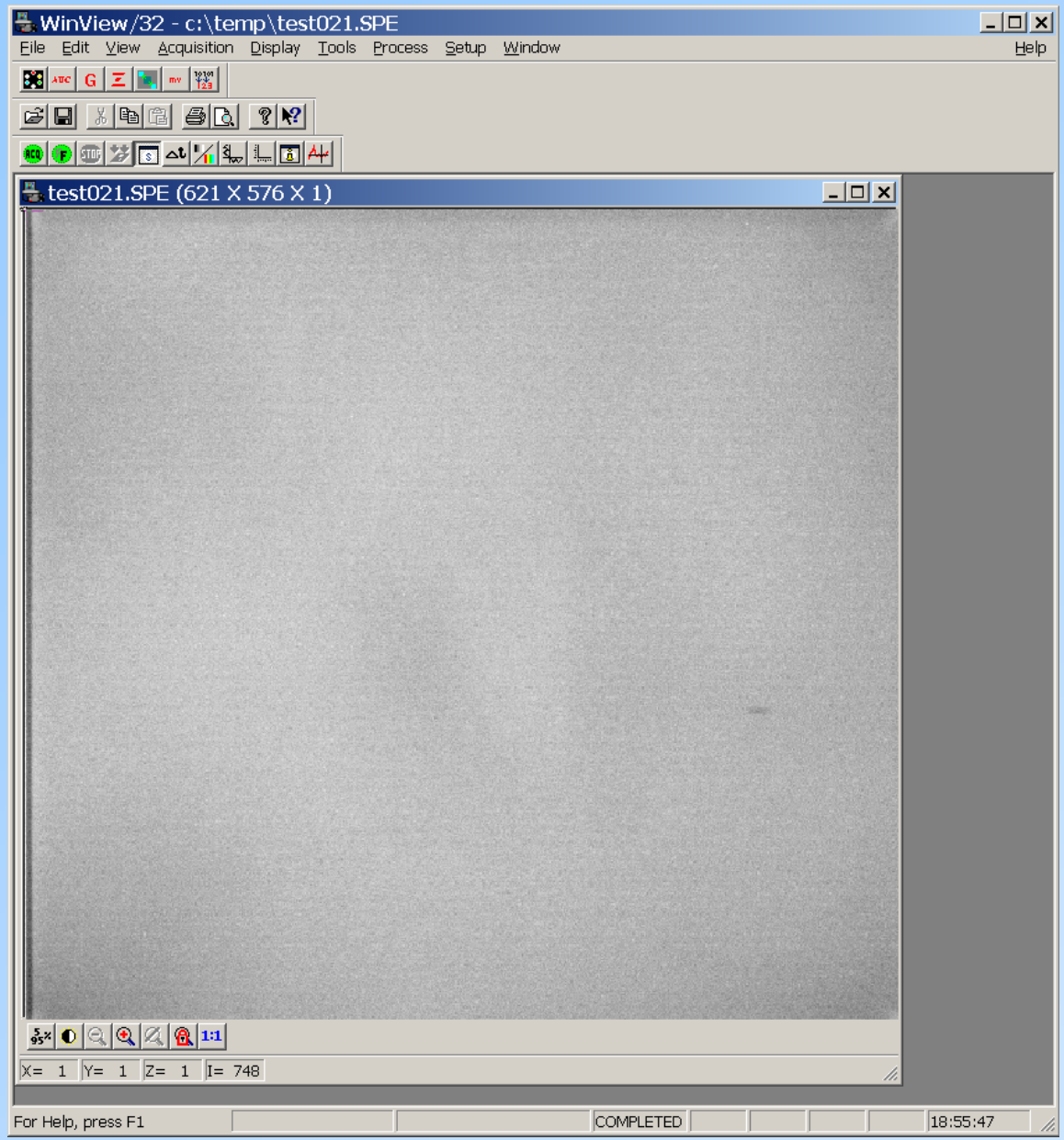


Many fields do not apply to all detectors. Simpler screens (e.g. for MAR 165 only) can easily be made.

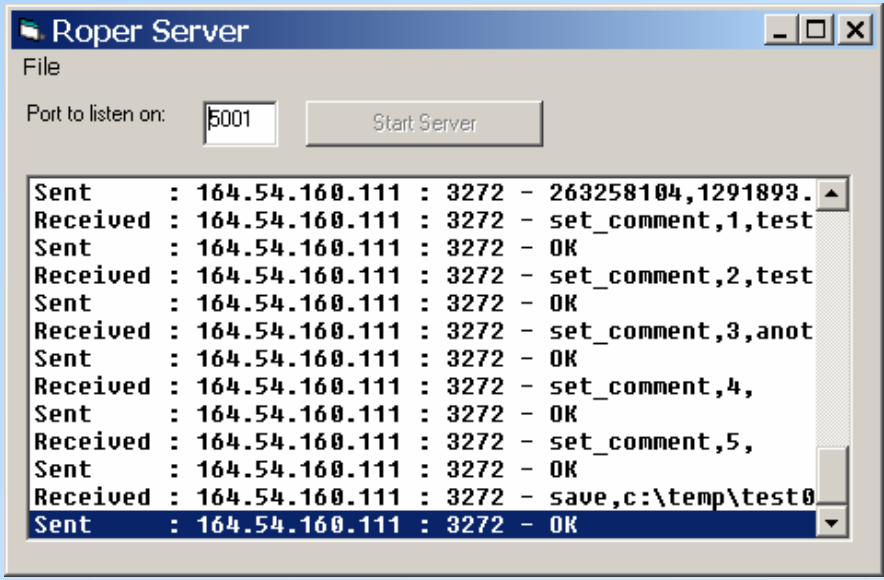
marccd remote control



Roper Interface



WinView (from Roper)



Socket server written in Visual Basic. Simple ASCII commands. Calls COM interface to automate WinView & WinSpec). Not EPICS specific, other applications can talk to it.

smartControl: Interfacing the Bruker SMART Software with EPICS

- Bruker makes x-ray detector systems for single-crystal and powder diffraction, and small-angle scattering applications.
- Widely deployed in crystallography laboratories world-wide
- Large user community who are familiar with the Bruker “SMART” control and analysis software.
- SMART software is only capable of controlling goniometers through the Bruker General Goniometer Control System (GGCS), which is a specific hardware controller manufactured by Bruker.
- GGCS is not generally used to control goniometers at synchrotron facilities.
- smartControl permits the standard Bruker SMART software to control any goniometer, with any number of axes, through EPICS. Also provides
  - Shutter control
  - Normalization information, such as from an ion chamber, to the SMART software where it is stored in the frame headers.

Closing the Loop: Using Feedback in EPICS

Mark Rivers, Center for Advanced Radiation Sources

- Many applications for feedback on APS beamlines
- Dedicated feedback controllers are expensive and relatively inflexible
- A new EPICS record for performing feedback
  - Enhanced Proportional Integral Derivative (EPID)
  - Flexible and fast feedback under EPICS

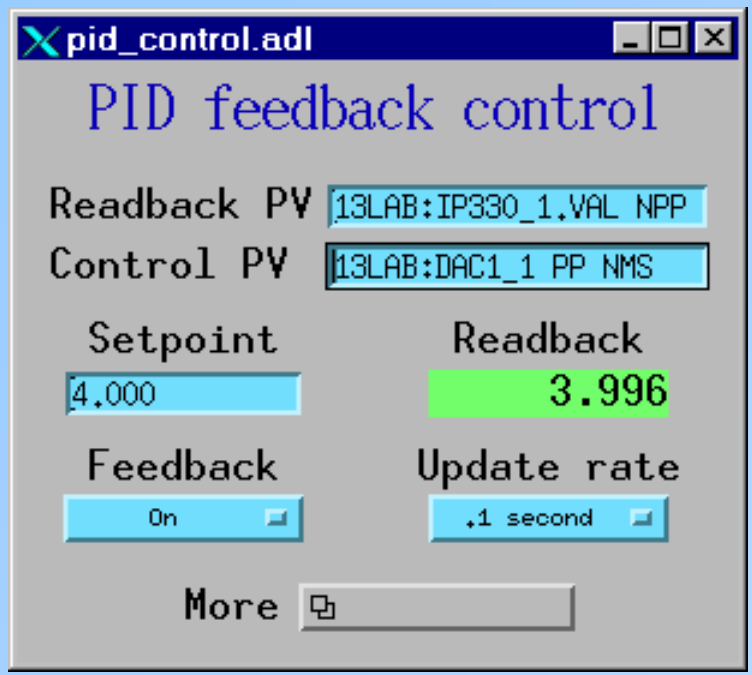
EPID record: Enhancements over the standard EPICS PID record

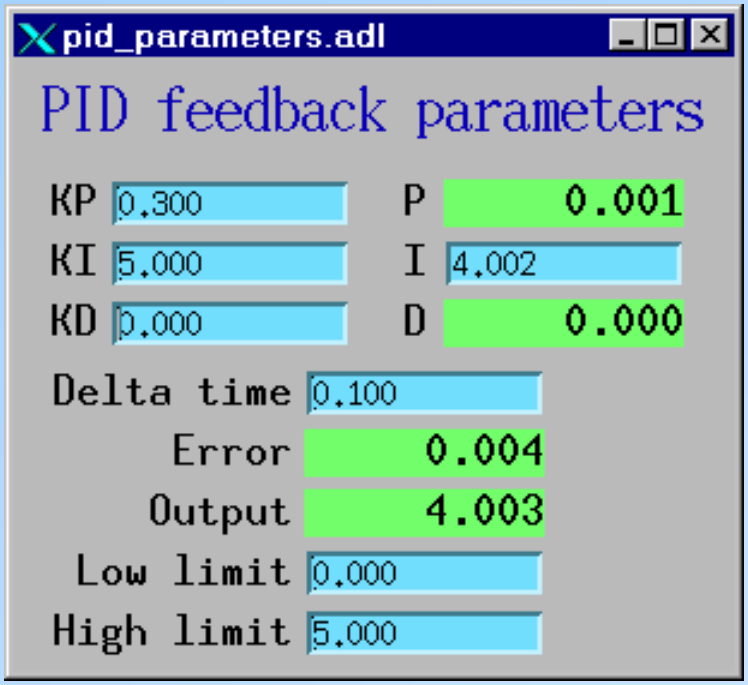
- Separation of device support from the record.
- Soft Record device support which uses EPICS database links
  - Very similar to the PID record
- EPID record can also be used with other device support
  - Communicate with faster feedback software
  - Hardware controllers.
- Addition of many fields (OUTL, DRVH, DRVL) to simplify construction of databases

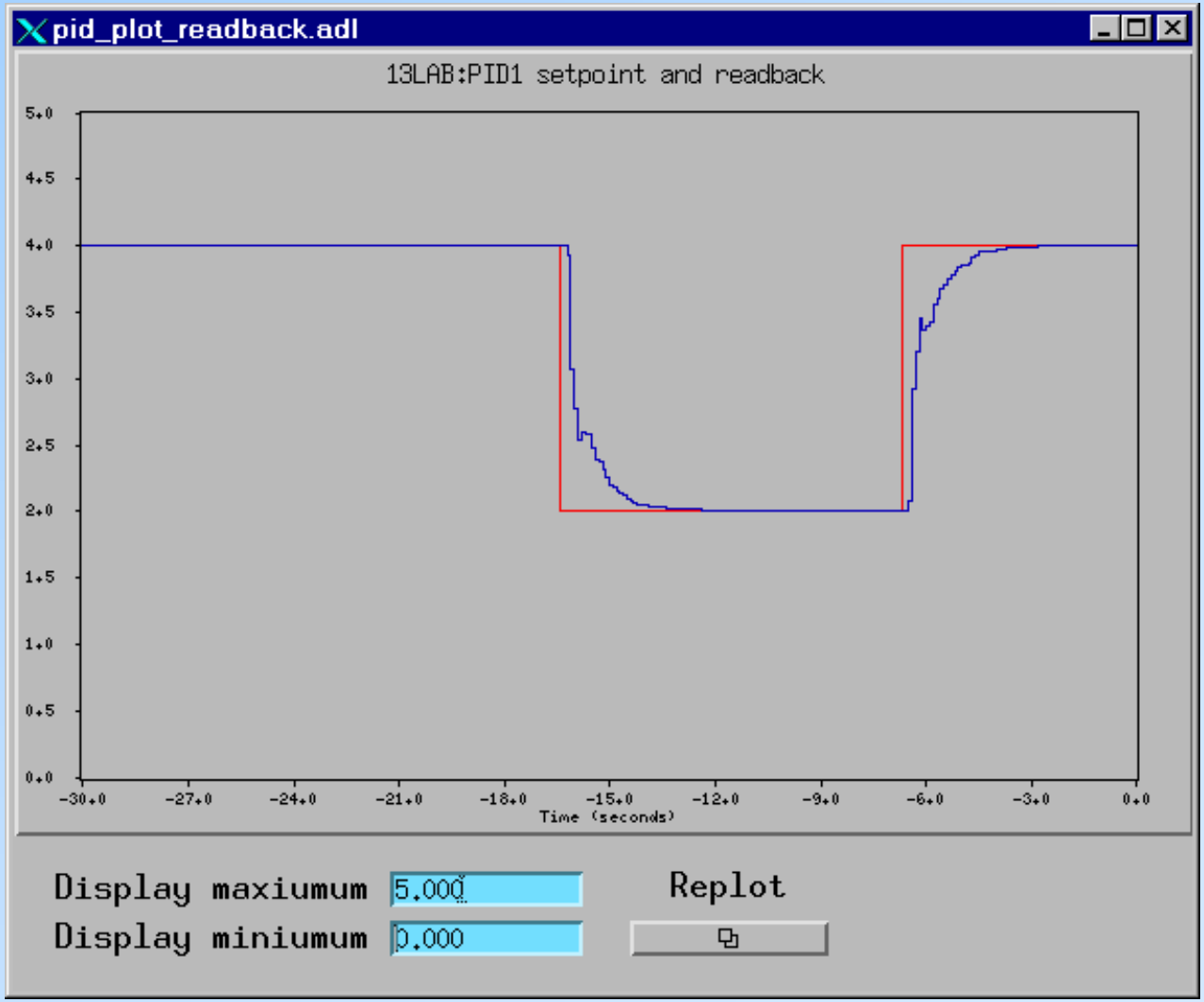
“Slow” Feedback

- The EPID record has two kinds of device support.
- “Soft” device support allows the readback input and control output to be any EPICS process variables.
  - Very flexible
  - Any type of device can be used for input (analog to digital converter, RS-232, GPIB, scaler, etc.)
  - Any type of device can be used for output (digital to analog converter, RS-232, GPIB, etc.)
  - Can be reconfigured on the fly, changing the input and outut process variables, feedback coefficients, etc.
  - Limited to standard EPICS scan rates, typically 10 Hz maximum
  - Sufficient for many applications

Slow feedback - D/A connected to A/D



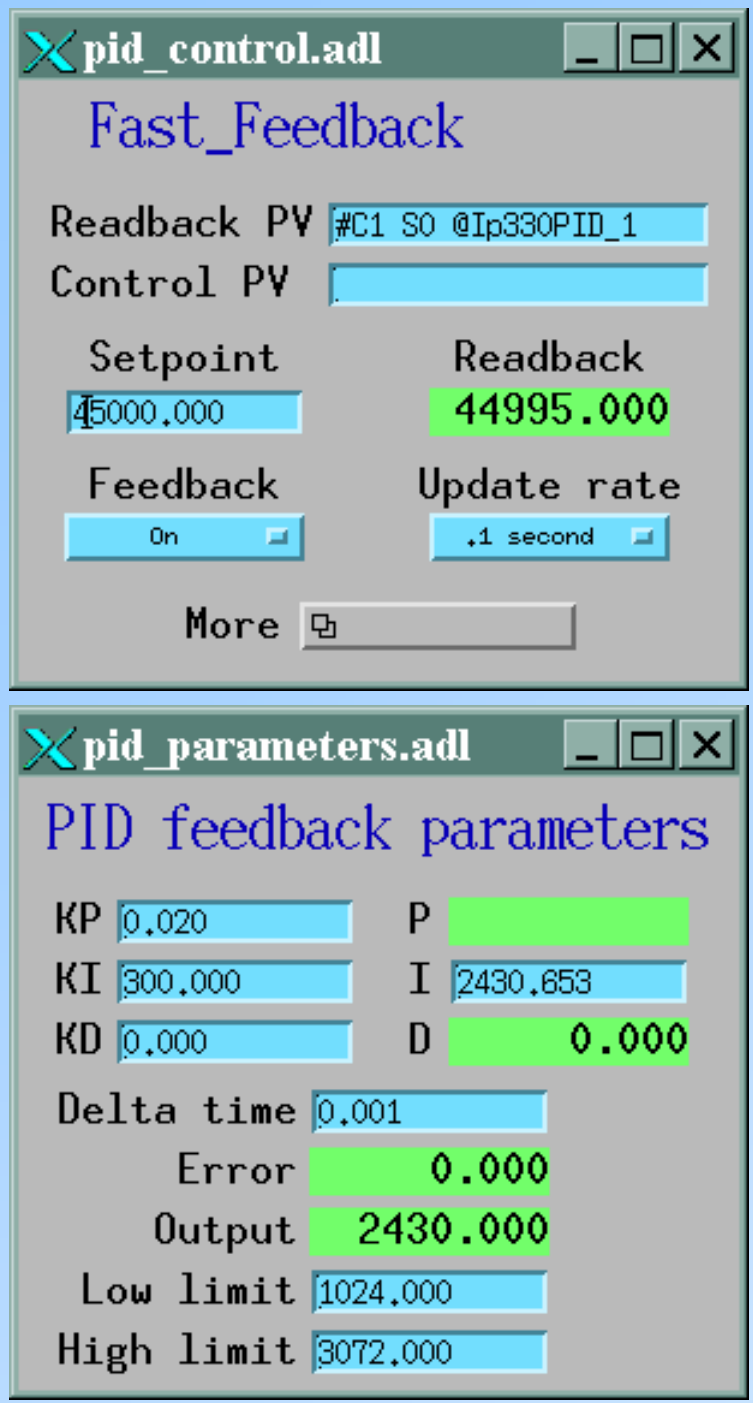


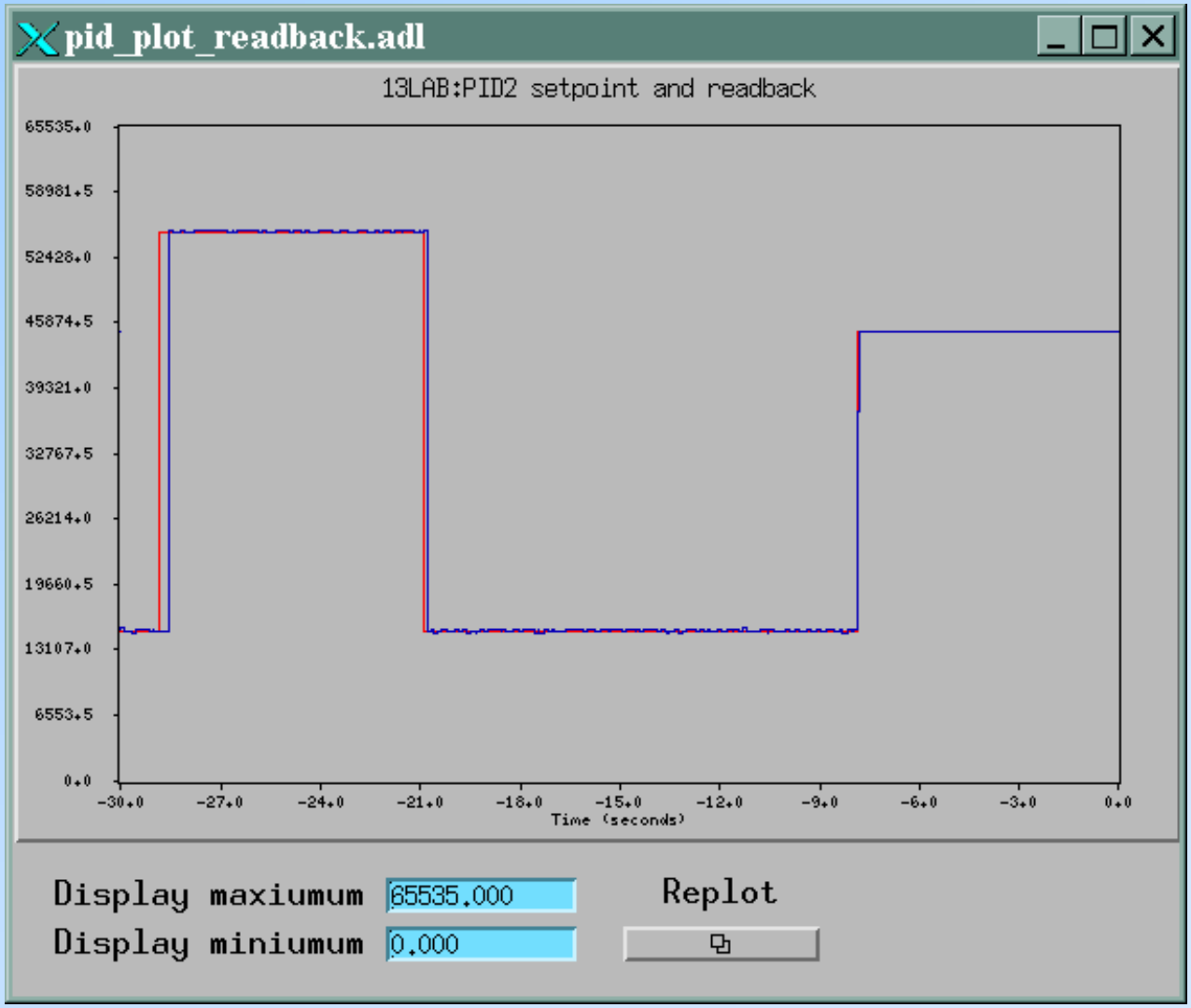


“Fast” Feedback

- Input from any driver that supports asynFloat64 with callbacks (e.g. callback on interrupt)
  - e.g. Acromag IP-300 ADC, APS quad-electrometer
- Output to any driver that supports asynFloat64.
  - e.g. Systran DAC-128V
- Very fast
  - Up to 10 kHz feedback rate
- Feedback coefficients and feedback rate be reconfigured on the fly

Fast feedback - D/A connected to A/D

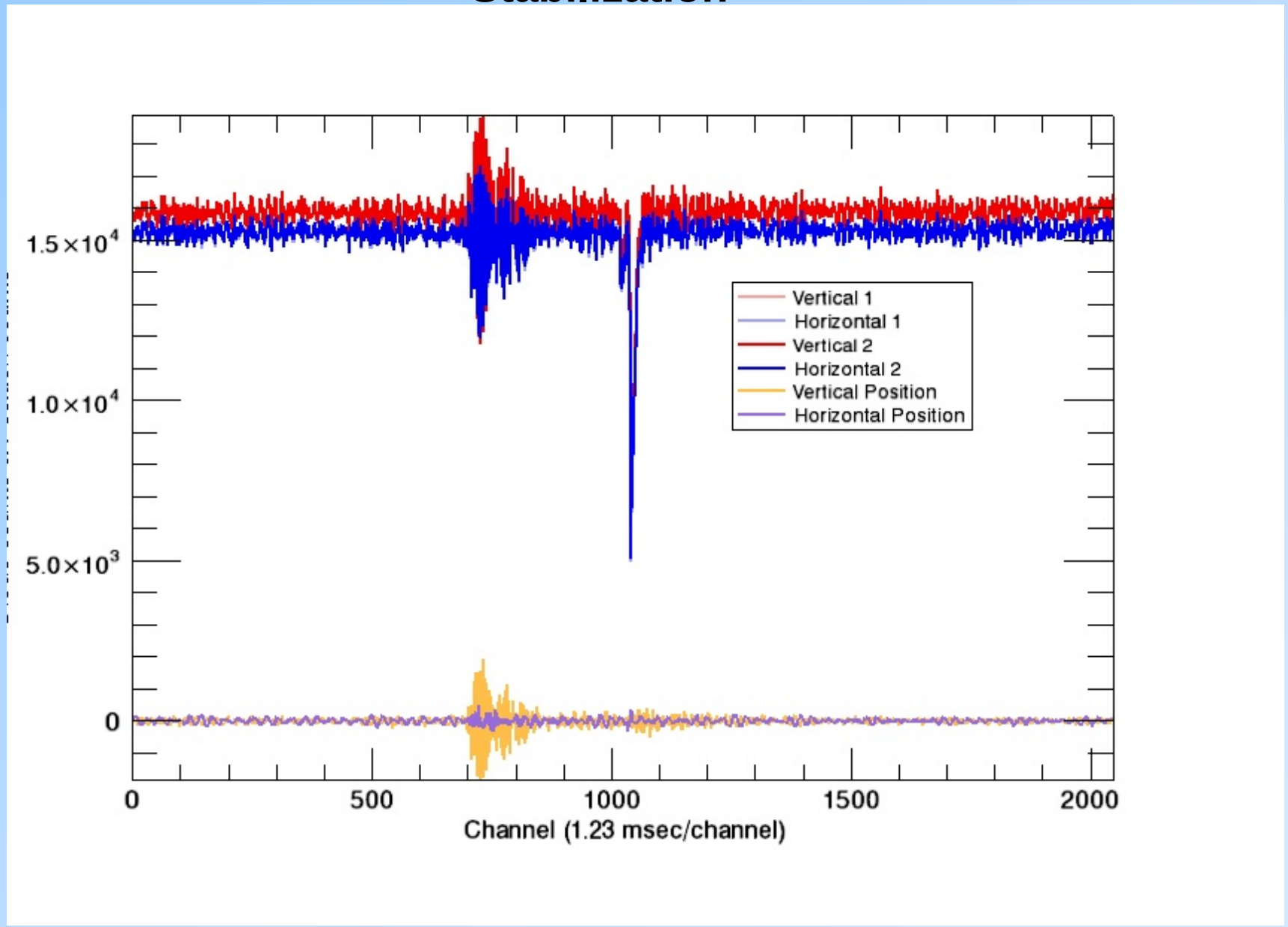




GSECARS Applications of EPID record

- Monochromator second crystal feedback:
  - Feedback on beam position on 13-ID, using photo-diodes in-vacuum slits, measuring scattered radiation from in-vacuum slits
  - Feedback on beam intensity on 13-BM, using table-top ion chamber.
  - Recovers gracefully from beam dumps. PV available to indicate "feedback locked", which data acquisition programs can wait for.
- Position feedback on large Kirkpatrick-Baez mirrors with piezo actuators. Stabilizes beam position at sample.
- Furnace temperature control in the large-volume press in 13-BM-D and 13-ID-D. Safety checks to limit voltage, current, and power.
- Pressure control in the large-volume press, via hydraulic pump, in 13-BM-D. Can ramp pressure up and down using scan record to control setpoint
- Temperature stabilization via laser power control in the laser-heated diamond-anvil cell in 13-ID-D.

Example Application: Monochromator Second Crystal Stabilization

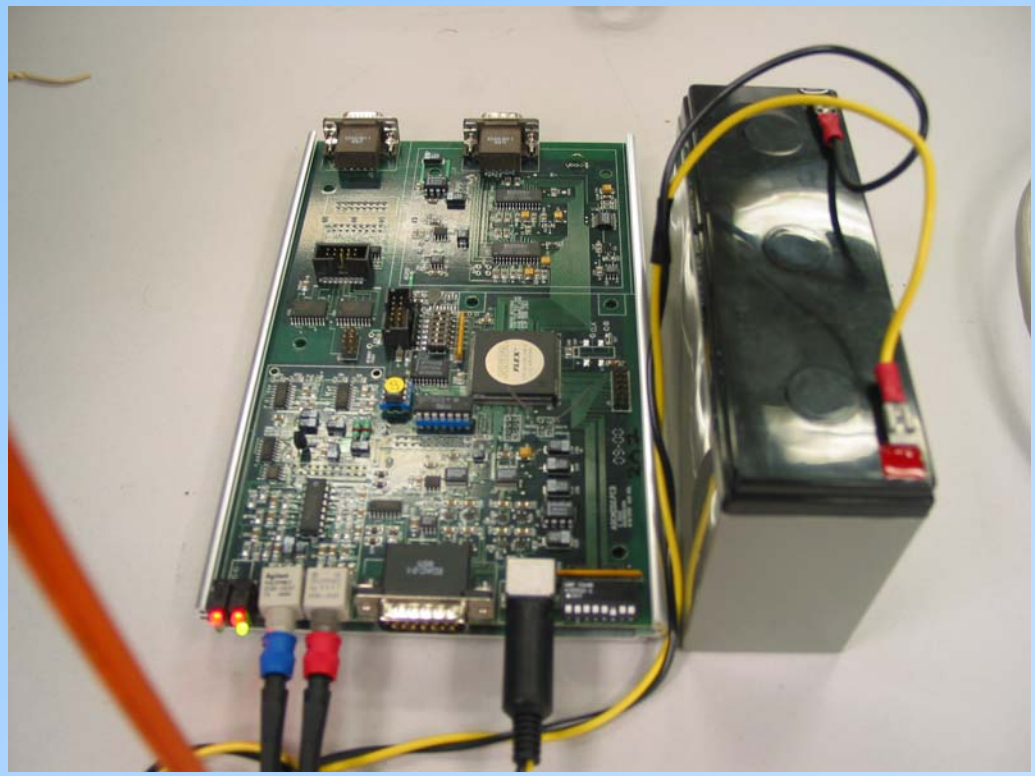


Hardware and EPICS Software for the APS Quad Electrometer for X-ray Beam Position Monitors

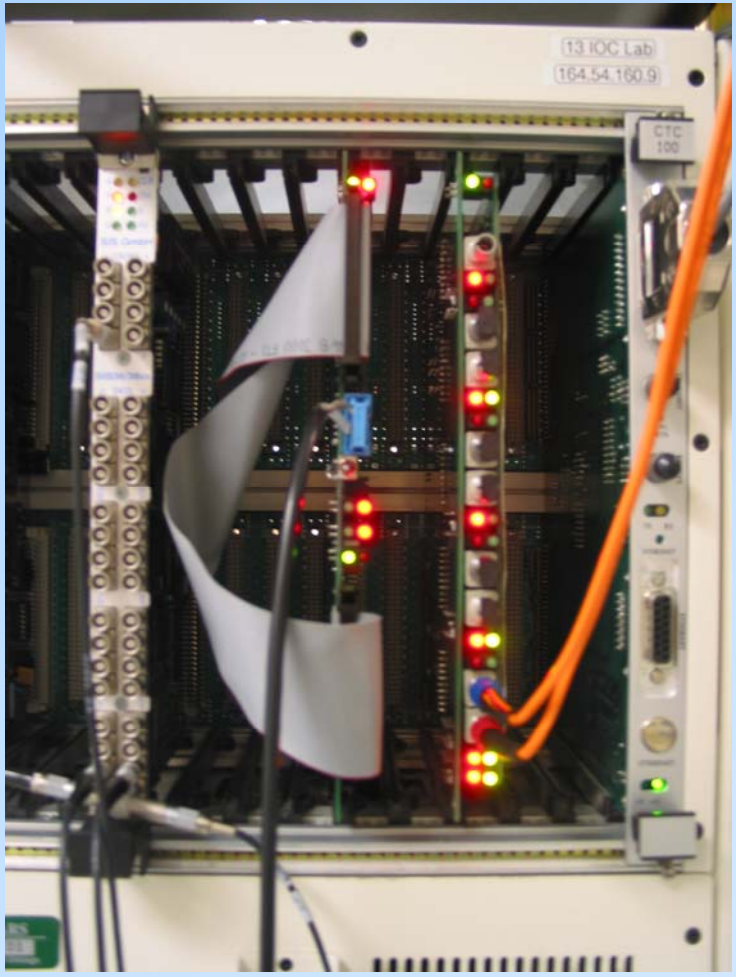
Mark Rivers (CARS) and Steve Ross(APS)

- Steve has designed a 4-channel electrometer for measuring currents in the nA to uA range.
- Intended primarily for reading x-ray beam positions using 4 photodiodes or split ion chambers.
- Compact and inexpensive, and can be placed close to the position monitor hardware to keep signal leads short.
- Outputs digital data at up to 815Hz over a fiber-optic cable
- Read by a pair of VME boards.
- Fiber allows reliable data transmission over long distances, for example from an experiment station to a VME crate in the FOE, where feedback to a monochromator crystal can be implemented.

Electrometer Hardware



Remote ADC unit and battery



VME boards

Applications

- Feedback of the pitch and roll of monochromator crystals based on the beam position in the beamline or experimental station.
- Feedback on mirror pitch for stabilizing the position of the beam downstream of a focusing mirror.
- In-vacuum fluorescent foils allow I0, beam position, and energy calibration to always be available
- Replaces:
  - 4 SRS570 current amplifiers
  - 4 ADCs, or 4 V/F converters and 4 scaler channels

EPICS Software

- I have developed a EPICS software (quadEM) to read the digital data from the electrometer.
- Interrupt driven, reads the digital data stream at 815Hz.
- Provides the current in each of the 4 photodiodes, as well as the sum, difference and position for opposite pairs of diodes.
- Device support is provided for 3 types of EPICS records:
  - analog input (ai) record at up to 10 Hz
  - multichannel analyzer (mca) record which functions as a “digital scope”, capturing the values at up to 815Hz
  - feedback (epid) record for fast feedback through an A/D converter at up to 815Hz.
- The mca and epid records can run slower than 815Hz as well, in which case they provide signal averaging.

New “asyn” motor record device/driver support

- Re-write the device and driver support layer for the EPICS motor record to use the new “asyn” module.
- Collaboration between APS (Mark Rivers, Ron Sluiter) and Diamond (Nick Rees and Peter Dennison)
- Problems with existing support
  - Relatively complex. New controller requires new device support and new driver support.
  - Difficult to understand interactions of “common” and device specific code
  - Difficult to take advantage of advanced controller features
  - Limited to using motor record to talk to driver, cannot use standard EPICS records
- Advantages of new support
  - Single device-independent device support file
  - Device-independent driver support file takes care of asyn interface
  - New controller requires implementing a driver with about 15 well-defined functions
    - motorAxisMove, motorAxisStop, motorAxisHome, motorAxisSetDouble, etc.
  - Easy to add additional functions to take advantage of controller-specific features such as I/O
  - Any record can talk to driver, not limited to motor record.
  - Plan to implement coordinated motions in a generic manner
- Status
  - Device-independent device and driver support are working
  - Drivers now exist for simulated motor, Newport XPS, Newport MM4000.
  - OMS-58, MAXv and Delta-Tau PMAC coming soon